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VEHICLE MOTION DURING SIDE IMPACT

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INTRODUCTION

Current Federal Safety standards for side impact protection contain a lateral static crush test and a dynamic side impact. The lateral static crush test utilizes a 6-inch diameter cylinder simulating a car-to-pole impact; the force deflection response must satisfy certain stiffness requirements. In the past several years substantial efforts have been undertaken by the National Highway Traffic Safety Administration (NHTSA) to develop a dynamic methodology for evaluating and improving vehicle safety in side impact. The dynamic standards include a 33.5 mph moving deformable barrier striking a stationary vehicle. The moving barrier, crabbed at 27 degrees with respect to the stationary vehicle, is fitted with a crushable aluminum honeycomb striking surface to simulate the front end of a car. The 27 degree crabbed barrier should accelerate the stationary vehicle differently than if the barrier was uncrabbed.

This paper discusses the response of the struck vehicle in a FMVSS 214 test. The struck vehicle is fitted with a nine acceleration plate that measures 3-dimensional (six degrees of freedom) motion, three translations and three rotations. The response is presented in terms of linear velocities and positions and angular velocity and positions.

METHOD

Acceleration Measurement

To record vehicle motion a triangular plate with a set of three interrelated triaxial accelerometers, a nine accelerometer array, was attached to the struck vehicle. The nine accelerometer array was located on the underside of the vehicle, attached to a rigid mechanical structure on the opposite side of the impact, and positioned along the center of impact, Figure 1. The SGA (1,2) methodology which measures angular velocity directly, was used to produce the vehicle motion from the nine accelerometer array. This arrangement of the nine accelerometers allows for determination of complete rigid body motion of the vehicle. The results, both angular and linear, are presented in the laboratory reference frame. The coordinate system is shown in Figure 1.

RESULTS

The following results represent a typical vehicle response in terms of linear and angular velocities and positions. In terms of the angular motion for the first 150 ms, Figure 2, 3, the magnitude of the angular velocity is relatively small, less than 2 rad/s for all three directions. However, the rotation about the Z axis, in terms of the angular position, becomes significant past 100 ms. In terms of the linear velocity and positions, Figure 4, 5, the dominate motion for the first 100 ms was in the Y direction; a slight motion is observed in the X direction, as a result of the angular velocity around the Z Axis; almost no motion is observed in the Z direction. Although this is a single example it represents the general trend across a wide variety of vehicles.

CONCLUSION

No comparison was done with a barrier that was crabbed at 0 degrees - the striking hexcell is aligned with the direction of motion of the barrier - however, it does seem that there would be very little difference between a direct "no crabbed" impact at 30 mph and the current configuration at 33.5 mph.

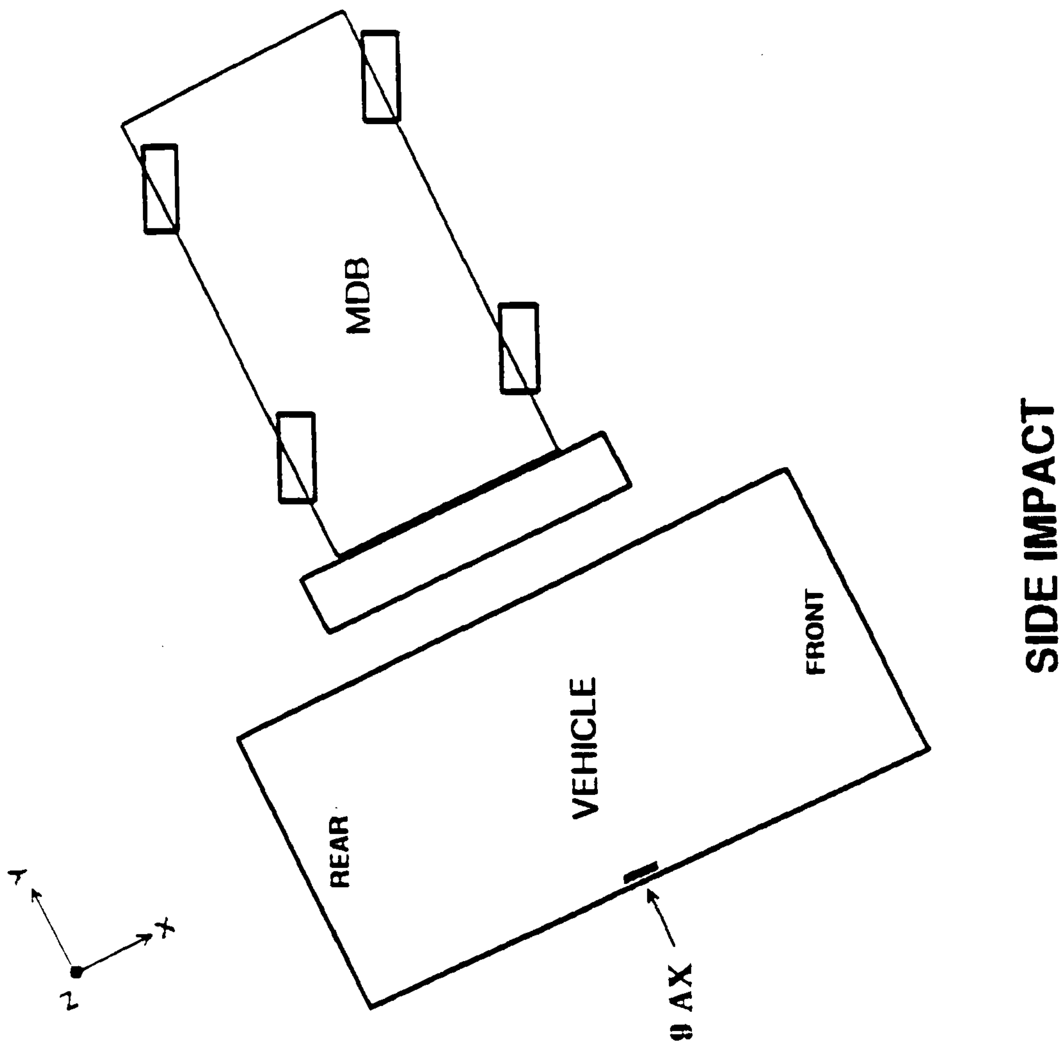


FIG. 1

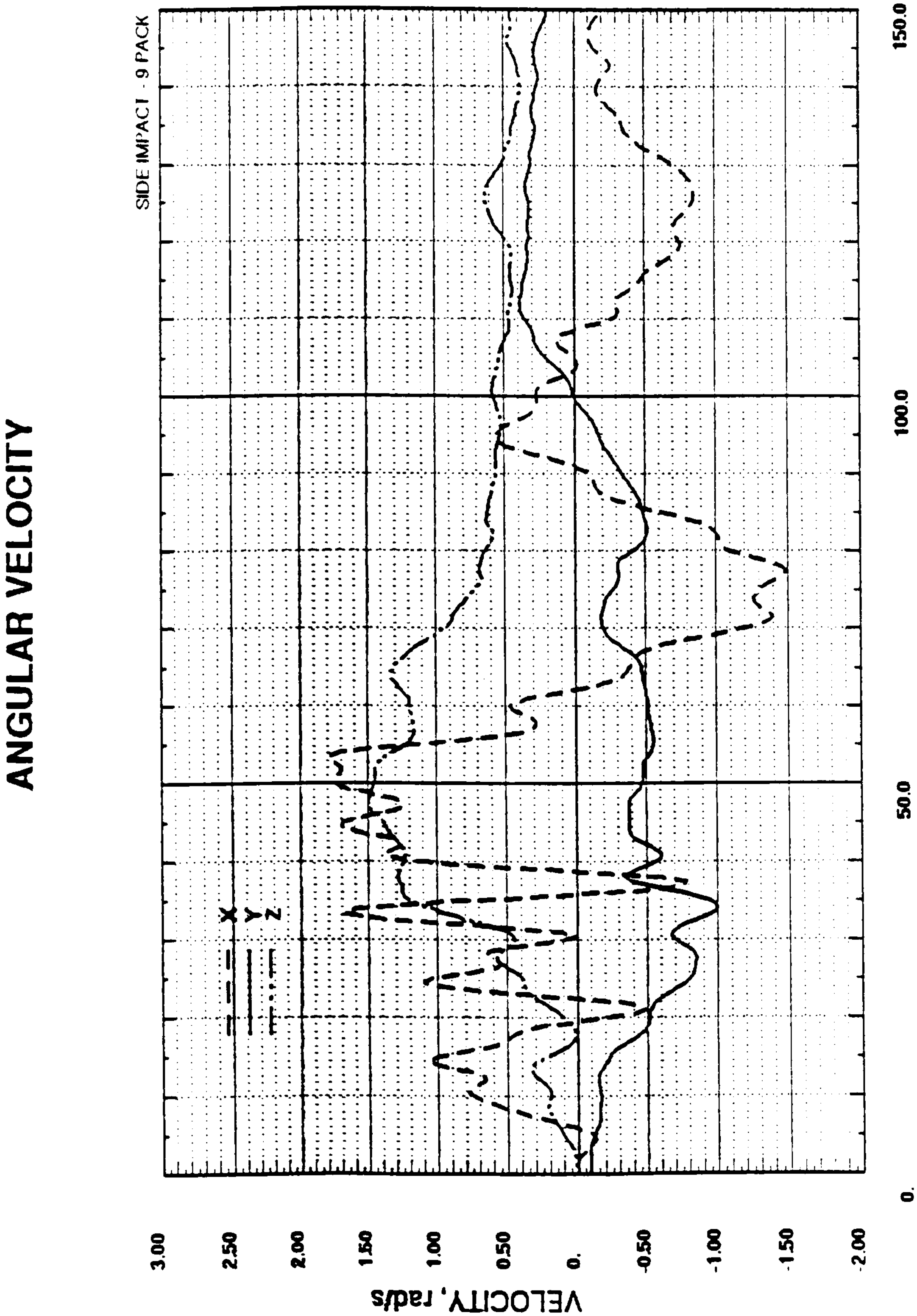
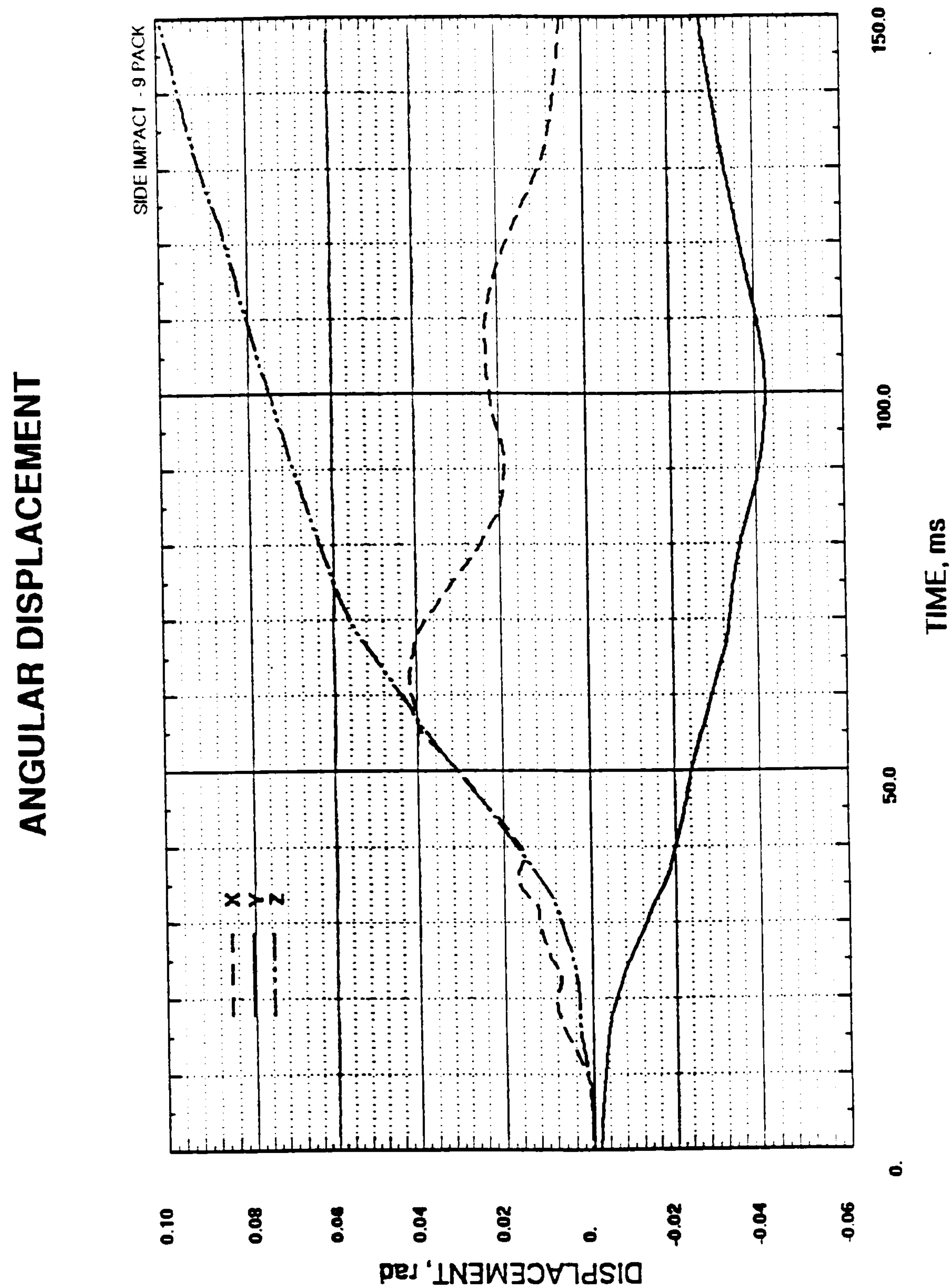

ANGULAR VELOCITY
SIDE IMPACT - 9 PACK
X
Y
Z
VELOCITY, rad/s
3.00
2.50
2.00
1.50
1.00
0.50
0.
-0.50
-1.00
-1.50
-2.00
TIME, ms
0.
50.0
100.0
150.0

FIG. 2



ANGULAR DISPLACEMENT
SIDE IMPACT - 9 PACK
X
Y
Z
0.10
0.08
0.06
0.04
0.02
0.
-0.02
-0.04
-0.06
DISPLACEMENT, rad
0.
50.0
100.0
150.0
TIME, ms

FIG. 3

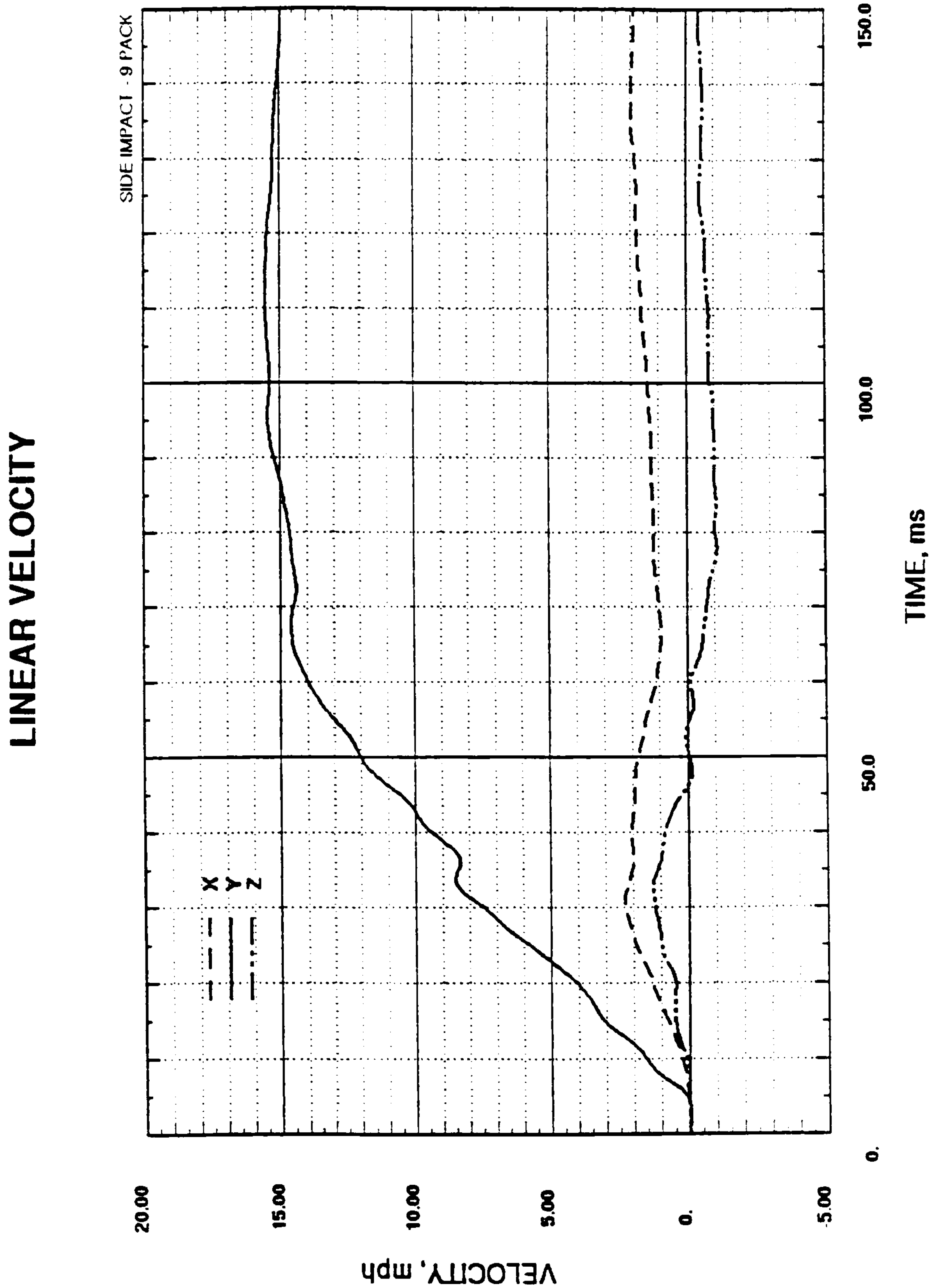

LINEAR VELOCITY
SIDE IMPACT - 9 PACK
X
Y
Z
TIME, ms
0.
50.0
100.0
150.0
VELOCITY, mph
20.00
15.00
10.00
5.00
0.
-5.00

FIG. 4

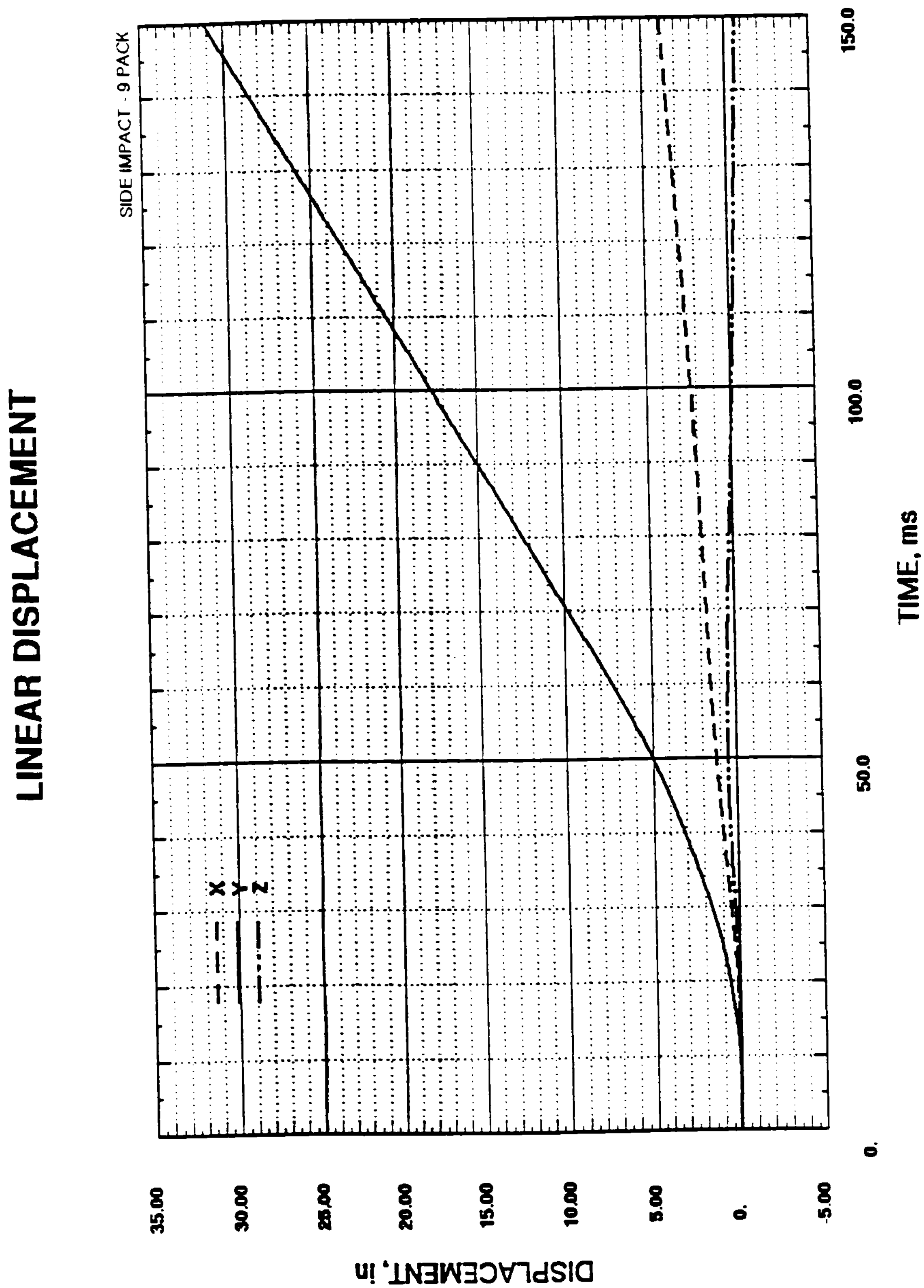

LINEAR DISPLACEMENT
SIDE IMPACT - 9 PACK
X
Y
Z
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.
-5.00
DISPLACEMENT, in
0.
50.0
100.0
150.0
TIME, ms

FIG. 5

REFERENCES

1. Nusholtz, G.S. and Molinaro, R., "Force Deflection Curves for Airbag Response", Experimental Techniques, Vol. 15, No. 2, March/April, 1991.

2. Nusholtz, G.S., et al, "Passenger Airbag Through Geometric Analysis at Rigid Body Motion, Experimental Mechanics, In press, 1991.

DISCUSSION

PAPER: **Vehicle Motion during Side Impact**

SPEAKER: Guy Nusholtz, Chrysler

QUESTION: Don Friedman, Liability Research

Have you compared this with any kind of crash test using real world vehicles in similar kinds of modes? What I'm asking is, Is the test, the 214 test in your opinion, at all representative of the real world of accidents for which we're trying to provide protection?

A: Well, I'm sort of going to answer that in terms of I have no opinion on that and the reason for that is that most of the concentration that I've been involved in is just understanding what does the 214 test mean in terms of dynamics of the vehicle. I haven't involved myself into trying to say is that representative of an actual real world case. You'd have to look at other people who have evaluated both the response of the vehicle as well as the response of actual real world, so someone else would have to answer that question.

Q: Richard Morgan, NHTSA

Guy, how far did you say the vehicle rises up in the verticle direction?

A: In this particular case it was about 5-7 centimeters; in some cases it will rise up a little more.

Q: Don Friedman, Liability Research

This observed rotation, does it have any significance in terms of providing protection to side impacts, now that you've discovered this rotation exists does it have any kind of effect in how you would modify the car to provide protection in side impacts?

A: Well, I don't know that I've discovered that because anybody who looks at a 214 barrier crash will see the vehicles move around in that direction. Does it offer any protection? Well there's a couple things that it does and I don't know if these offer protection but it does rotate the vehicle so that the seat moves a little bit out from under the occupant, maybe 2 or 3 centimeters.

Q: On the near side?

A: On the side closest to the barrier; which would be the near side.

Q: But you're considering gross motion of the vehicle in a non-deforming part of the vehicle and most of the structure on the near side is deforming much more rapidly and I would imagine has all occurred prior to any significant rotation and I was just wondering what would be the significance of this observation be when your trying to induce protection on the near side with a high velocity intruding structure?

A: Actually I can't see how this would improve; understanding that rotation basically tells us what is happening in the vehicle. It doesn't give us any tools at least, at this time, we haven't applied any of those tools improving occupant protection. The only thing it does do in terms of that, is it makes it simpler to simulate on a sled if you're trying to address certain aspects of the door.

Q: So you find this significant that you feel you should incorporate this rotation in a sled?

A: Not that we need to incorporate this into a sled but that it's small enough that we don't need to incorporate it. We don't need to incorporate a 50mph vector in the other component. The significance boils down to, it's really a 30mph frontal crash into the side; the 50mph vector-all it does is produce a momentum or a rotation in the vehicle which doesn't really affect the response of anything. It's something extra which causes a rotation that you see in a long duration type of motion.